SECTION 7 – CONDUCTIVITY

SUMMARY

As a result of the 1998-1999 SWQB/NMED monitoring effort in the Jemez River Basin, several exceedances of New Mexico water quality standards for conductivity were documented on Sulphur Creek. Figures 5.A.1 and 5.A.2 in Section 5 show the land use/cover and land ownership percentages, respectively, for the segment of Sulphur Creek listed for this constituent (Sulphur Creek from the mouth at Redondo Creek to the headwaters). A detailed description of this segment can be found in Section 5, Subsection A of this document.

Photo 18. Sulphur Creek (NMED Sampling Station 12 – Thermograph T9)

ENDPOINT IDENTIFICATION

Target Loading Capacity

Overall, the target values are determined based on 1) the presence of numeric criteria, 2) the degree of experience in applying the indicator, and 3) the ability to easily monitor and produce quantifiable and reproducible results. For this TMDL document the target value for conductivity is based on numeric criteria, which is consistent with the State's antidegradation policy.

Conductivity

The New Mexico Water Quality Control Commission (WQCC) has adopted numeric water quality standards for conductivity to protect the designated use of high quality coldwater fishery (HQCWF). These water quality standards have been set at a level to protect cold-water aquatic life. The HQCWF use designation requires that a stream have water quality, streambed characteristics, and other attributes of habitat sufficient to protect and maintain a HQCWF. The primary standard leading to an assessment of use impairment is the numeric criteria for conductivity of 400 μmhos/cm.

Flow

Conductivity in a stream can vary as a function of flow. As flow decreases, the concentration of total dissolved solids (TDS) can increase, thereby increasing the conductivity. Similarly, as flows decline, temperatures have a tendency to increase, thus affecting conductivity values. These TMDLs are calculated for each reach at a specific flow.

Estimated 4Q3 flow for Sulphur Creek

The flow value used to calculate the TMDL for conductivity on Sulphur Creek was obtained using a 4-day, 3-year low-flow frequency (4Q3) regression model. The 4Q3 is the annual lowest 4 consecutive day period discharge that will not fall below that discharge at least every 3 years (USGS, 2001). Low flow was chosen as the critical flow because the exceedances of the conductivity standard occurred only during low flow periods (July and November 1998).

It is often necessary to calculate a critical flow for a portion of a watershed where there is no flow gage as in Sulphur Creek. This can be accomplished by applying one of two formulas developed by the USGS. The first formula (Waltemeyer, 1987) is recommended when the ratio between the two watershed areas is between 0.5 and 1.5. The other formula, to be used when the watershed ratio is outside this range, is a regression formula also developed by the USGS (Borland, 1970).

1) The nearest gage to the point of interest is the Rio Guadalupe at Box Canyon (08323000). The drainage area above this gage (A_g) is 268 mi^2. The watershed above the area of interest (A_u) is 25 mi^2. The ratio of watershed size (25/268) is 0.09. Because this ratio value is less than 0.5, the guidelines recommended by USGS are applied and the formula for calculating 7Q2 in step 2 is used.

2)

$$Q_{7/2} = 1.36\text{x}10^{-4} \text{ x } (A_u)^{.566} \text{ x } (P_a)^{3.22}$$

Where,
A_u = Watershed area of interest, in square miles
P_a = Mean precipitation (October thru April), in inches

Thus,

$$Q_{7/2} = 1.36\text{x}10^{-4} \text{ x } (25)^{.566} \text{ x } (11)^{3.22}$$

$$Q_{7/2} = 2.0 \text{ cfs}$$

3) The plot of the 1-day, 3-day, and 7-day low flow events at this gage as well as the model verification is described in the TMDL document written for Redondo Creek (SWQB/NMED, 1999). From the reference graph, the $Q_{4/3}$ low flow is 5.5 cfs. The $Q_{7/2}$ is 6.3 cfs. The ratio (R) of $Q_{4/3}$ /$Q_{7/2}$ is 0.87.

4) Multiplying the $Q_{7/2}$ value from step 2 ($Q_{7/2} = 2.0$ cfs) and the ratio from step 3 (R = 0.87), the estimated 4Q3 value is:

$$Q_{4/3(est)} = R \times Q_{7/2}$$
$$Q_{4/3(est)} = 0.87 \times 2.0 \text{ cfs}$$

$$\mathbf{Q_{4/3(est)} = 1.74 \text{ cfs} = 1.12 \text{ MGD}}$$

It is important to remember that the TMDL is a planning tool to be used to achieve water quality standards. Since flows vary throughout the year in these systems the target load will vary based on the changing flow. Management of the load to improve stream water quality should be a goal to be attained; meeting the calculated target load may be a difficult objective.

Calculations

Specific conductance (SC) may be used to estimate the total ion concentration of a surface water sample, and is often used as an alternative measure of dissolved solids. In order to calculate a load in lb/day, TDS is used as a surrogate for conductivity. The total dissolved solids to specific conductance ratio ranges from 0.5 to 0.9 mg/L/(µmhos/cm) (American Public Health Association, 1997). Specific correlation should be derived by site, if TDS values are available.

TDS values were obtained for Sulphur Creek during the 1998-1999 SWQB/NMED sampling season. These values as well as the SC values measured on Sulphur Creek are located on Table 7-6 at the end of this section. The TDS to SC ratio values were calculated, and averaged, resulting in a correlation of 0.84 (mg/L)/(µmhos/cm). State Standards to protect the designated HQCWF use states that SC for Sulphur Creek shall not exceed 400µmhos/cm. Using the above mentioned reference correlation, Equation 1 provides a procedure for Sulphur Creek:

Equation 1. TDS (mg/L)≅SC (µmhos/cm)*(0.84)
Specific Conductance to achieve state standards= 400 µmhos/cm
400 µmhos/cm * (0.84 correlation factor)≅ 336 mg/L of TDS

For the purpose of TMDL development, a TDS criterion of 336 mg/L was used. This TMDL was developed based on simple dilution calculations using average flow and the TDS criterion of 336 mg/L (from Equation 1). The TMDL calculation includes wasteload allocations, load allocations, and a margin of safety.

Target loads for total dissolved solids (TDS) are calculated based on a flow, the current water quality standard, and a unit-less conversion factor of 8.34, that is used to convert mg/L units to lb/day (see Appendix A for Conversion Factor Derivation).

Equation 2.

Critical Flow (MGD) x Standard (mg/L) x 8.34 (conversion factor) = Target Loading Capacity

The target loads (TMDLs) predicted to attain standards were calculated using Equation 2 and are shown in Table 7-1.

Table 7-1: Calculation of Target Loads

Location	Flow* (MGD)	Standard** TDS (mg/L)	Conversion Factor***	Target Load Capacity (lb/day)
Sulphur Creek	1.12	336	8.34	3,139

*Flow is the 4Q3 value calculated on the previous pages.
**TDS is used as a surrogate measure for conductivity in order to calculate a load in lb/day. The actual standard is 400(μmho/cm). This value is the converted value into TDS, or 400 μmho/cm × correlation factor (See Table 7-6).
***Conversion factor used to convert mg/L to lb/day (See Appendix A).

Background loads were not possible to calculate in this watershed. A reference reach, having similar stream channel morphology and flow, was not found. It is assumed that all or a portion of the load allocation is made up of natural background loads. In future water quality surveys, finding a suitable reference reach will be a priority.

The measured loads were also calculated using Equation 2. In order to achieve comparability between the target and measured loads, the flowrate used was the same for both calculations. The same conversion factor of 8.34 was used. Results are presented in Table 7-2.

Table 7-2: Calculation of Measured Loads

Location	Flow* (MGD)	Field Measurement TDS (mg/L)**	Conversion Factor***	Measured Load (lb/day)
Sulphur Creek	1.12	604.2	8.34	5,644

* Flow is the 4Q3 value calculated on the previous pages.
**The field measurement was the geometric mean of the specific conductance exceedances, converted to TDS (See Table 7-6).
***Conversion factor used to convert mg/L to lb/day (See Appendix A).

Waste Load Allocations and Load Allocations

•*Waste Load Allocation*
There are no point source contributions associated with this TMDL. Therefore, waste load allocation is zero.

•*Load Allocation*
In order to calculate the Load Allocation (LA), the waste load allocation (WLA) and margin of safety (MOS) were subtracted from the target capacity (TMDL), as shown below in Equation 3.

Equation 3. $WLA + LA + MOS = TMDL$

Results using a Margin of Safety (MOS) of 15% (as explained on the following page), are presented in Table 7-3.

Table 7-3: Calculation of TMDL for TDS (Specific Conductance Surrogate)

Location	WLA (lb/day)	LA (lb/day)	MOS (15%) (lb/day)	TMDL (lb/day)
Sulphur Creek	0	2,668.1	470.9	3,139

The load reduction that would be necessary to meet the target load was calculated to be the difference between the load allocation (Table 7-3) and the measured load (Table 7-2), and is shown in Table 7-4, Calculation of Load Reduction.

Table 7-4: Calculation of Load Reduction for TDS (Specific Conductance Surrogate), in lb/day

Location	Load Allocation (lb/day)	Measured Load (lb/day)	Load Reduction (lb/day)
Sulphur Creek	2,668	5,644	2,976

Identification and Description of Pollutant Source(s)

Pollutant sources that could contribute to Sulphur Creek are listed in Table 7-5.

Table 7-5: Pollutant Source Summary

Pollutant	Magnitude (WLA + LA + MOS) (lb/day)	Location	Potential Sources (% from each)
Point: None	0	--------	0
Nonpoint: Total Dissolved Solids (TDS)	3,139	Sulphur Creek	100% Unknown and Natural

LINK BETWEEN WATER QUALITY AND POLLUTANT SOURCES

Where available data are incomplete or where the level of uncertainty in the characterization of sources is large, the recommended approach to TMDLs requires the development of allocations based on estimates utilizing the best available information.

SWQB fieldwork includes an assessment of the potential sources of impairment (SWQB/NMED, 1999). The Pollutant Source(s) Documentation Protocol, shown as Appendix B, provides an approach for a visual analysis of a pollutant source along an impaired reach. Although this procedure is subjective, SWQB feels that it provides the best available information for the identification of potential sources of impairment in this watershed. Table 7-5 (Pollutant Source Summary) identifies and quantifies potential sources of nonpoint source impairments along each reach as determined by field reconnaissance and assessment. A further explanation of the sources follows.

Sulphur Creek

(Analysis of the Sulphur Creek is currently on hold. EPA is waiting for the State to prepare a new draft for the UAA). The sources of impairment to Sulphur Creek currently are unknown but, upon analysis of the stream, the sources are considered to be natural.

MARGIN OF SAFETY (MOS)

TMDLs should reflect a margin of safety based on the uncertainty or variability in the data, the point and nonpoint source load estimates, and the modeling analysis. For this TMDL, there will be no margin of safety for point sources, since there are none. However, for the nonpoint sources the margin of safety for Specific Conductance is estimated to be an addition of 15% of the TMDL, excluding the background. This margin of safety incorporates several factors:

•*Errors in calculating NPS loads*

A level of uncertainty exists in sampling nonpoint sources of pollution. Accordingly, a conservative margin of safety increases the TMDL by 10%.

•*Errors in calculating flow*

Flow estimates were based on the estimation of the 4Q3 for ungaged streams and compared to actual flows and cross-sectional information taken in the field. Techniques used for measuring flow in Sulphur Creek water have a (±) 5% precision. Accordingly, a conservative margin of safety increases the TMDL by 5%.

CONSIDERATION OF SEASONAL VARIATION

Data used in the calculation of this TMDL were collected during high and low flow seasons in order to ensure coverage of any potential seasonal variation in the system. Exceedances, shown in Table 7-6, were observed during Summer monsoonal rains (July 13 & 14, 1998), and again on November 2, 1998. Exceedances were not seen, however, during the Spring runoff (April, 1998). The critical condition used for calculating the TMDL was low flow. Data that exceeded the standard for conductivity were used in the calculation of the measured loads and can be found in Table 7-6 at the end of this section.

FUTURE GROWTH

Estimates of future growth are not anticipated to lead to a significant increase in Specific Conductance that cannot be controlled with best management practice implementation in this watershed.

TABLE 7-6: CONDUCTIVITY RESULTS DURING 1998-1999 SAMPLING EFFORT (SULPHUR CREEK)

		MEASURED VALUES		
Location	**Date**	**Specific Conductance (SC) (μmho/cm)**	**Total Dissolved Solids (TDS) (mg/L)**	**TDS to SC Ratio (Site Specific)**
Sulphur Creek At State Hwy 4 (Station 12)	4/20/1998	244.1	188	0.77
	4/21/1998	189.8	152	0.80
	4/22/1998	157.8	170	1.08
	4/23/1998	123.5	146	1.18
	7/13/1998	* 621	484	0.78
	7/14/1998	* 705	512	0.73
	11/2/1998	* 850	472	0.56
	Geometric Mean of *Exceedances =	**719.30**	**Average of Ratios = (Correlation Factor)**	**0.84****

The Geometric Mean of Exceedances converted to TDS = 719.3 x 0.84 = 604.2 mg/L

*The geometric mean of field data that exceeded the State Standards was **719.3 μmho/cm**

**The acceptable range for this ratio is from 0.55 to 0.9. If the ratio of TDS to SC is outside these limits, an unmeasured constituent such as ammonia or nitrate may be present in significant concentrations (Standard Methods, 1997). All of the sample stations in this reach displayed nitrates in the water quality samples. The site-specific average for the TDS to SC ratio was 0.84. The individually calculated ratios that were outside the limit given by Standard Methods are probably due to nitrate concentrations that are present in the samples. The site-specific average of ratios of 0.84 was used to calculate the TMDL to reflect stream conditions.